

Global Macro Outlook AI: Methodology, Formula, Indicator, and Data Source Reference

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A. Executive Summary

Global Macro Outlook AI is an MVP macroeconomic intelligence dashboard for research, teaching, and decision-support. It presents country profiles, global risk rankings, regime classifications, simple forecasts, adapter health diagnostics, and AI-style country outlook reports.

The current codebase prioritizes transparency over model complexity. It uses deterministic demo/fallback data for the dashboard calculations in `src/lib/data/service.ts`, while live API adapters are implemented primarily through the adapter layer and data-source health checks. Some adapters can fetch live data when mappings and API keys are available, but the current country dashboard and scoring workflow call `getDemoObservations(...)` directly. Therefore, the main dashboard scores should be interpreted as demo-mode calculations unless the service layer is later changed to merge live adapter series into country views.

The app displays live/demo state, endpoint metadata, missing-key messages, parser errors, mapping errors, network errors, and source access restrictions where those fields are available. This makes source quality visible rather than hiding fallback behavior.

B. Scope of the Dashboard

The app contains these major modules:

- Home: landing page for the MVP.
- Global Dashboard: cross-country risk heatmap, top inflation/fiscal/external lists, commodity snapshot, market snapshot, and global outlook summary.
- Country Macro Profiles: country-level metrics, charts, risk radar, regime classification, CPI forecast, and AI-generated outlook.
- Inflation Tracker: CPI, wage growth, oil price, food proxy, and inflation-pressure score.
- Central Bank Monitor: policy rate, real policy rate, yield-curve slope, and rule-based policy stance.
- Fiscal Risk Monitor: debt-to-GDP, fiscal balance, nominal GDP growth, debt arithmetic, and fiscal stress.

- Credit Cycle Dashboard: credit growth, non-performing loans, yield curve, and credit stress.
- External Vulnerability: current account, FX versus USD, reserves, and external vulnerability score.
- Commodity and Energy Tracker: oil, natural gas, copper, food proxy, and commodity shock explanation.
- Forecasting Lab: moving-average, linear-trend, and last-observation-carried-forward CPI forecasts.
- AI Country Report: deterministic or OpenAI-generated country outlook from indicators, scores, and regime.
- Data Sources / Adapter Health: data adapter status, endpoint metadata, fallback reason, and indicator coverage.
- Methodology: in-app summary of score categories, regime logic, forecasting limits, and extension notes.

C. Countries Covered

The current country list is defined in `src/lib/constants.ts`.

Country/economy	App code	World Bank/adapter code	Inflation target	Commodity exposure
United States	US	USA	2	mixed
Canada	CA	CAN	2	exporter
Euro Area	EA	EMU / EAQ	2	importer
China	CN	CHN	3	importer
Japan	JP	JPN	2	importer
United Kingdom	GB	GBR	2	importer
Germany	DE	DEU	2	importer
India	IN	IND	4	importer
Brazil	BR	BRA	3	exporter
Mexico	MX	MEX	3	mixed

D. Complete Indicator Inventory

The indicator definitions are in `src/lib/constants.ts`. Demo series are generated in `src/lib/demo-data.ts`. The `Formula` or `direct-source` value column below distinguishes direct observed values from derived fields.

Indicator name	Variable/code	Module/page where it appears	Unit	Frequency	Source or fallback source	Live/demo/fallback status	Formula or direct-source value	Notes
Real GDP growth	GDP_GROWTH	Country, Dashboard, Fiscal, Forecast/AI inputs	% y/y	annual	World Bank / national sources / demo cache	Dashboard uses demo cache; World Bank/OECD/IMF adapters can fetch where configured	Direct source/demo value	Used in growth momentum, nominal growth proxy, and regime classification.
CPI inflation	CPI	Country, Inflation, Forecasting, AI Report	% y/y	monthly	BLS, FRED, World Bank, OECD/IMF mappings, demo cache	Dashboard uses demo cache; live adapters available where configured	Direct source/demo value	Used in inflation pressure, real policy rate, regime classification, and forecasts.
Unemployment	UNEMPLOYMENT	Country, Inflation/AI	%	monthly	BLS, FRED, World Bank,	Dashboard uses demo	Direct source/demo	Delta over four periods

		inputs, Regime			OECD/IMF mappings, demo cache	cache; live adapters available where configured	value	feeds growth risk and regime rules.
Wage growth	WAGE_GROWTH	Inflation, scoring, AI report context	% y/y	monthly	BLS / national sources / demo cache	Dashboard uses demo cache; BLS adapter maps U.S. wage proxy with key	Direct source/demo value	If missing in scoring, defaults to CPI.
Policy rate	POLICY_RATE	Country, Central Bank, Forecasting scenarios	%	monthly	Central banks, FRED, Bank of Canada, BIS, demo cache	Dashboard uses demo cache; live adapters available for selected countries	Direct source/demo value	Used in real policy rate, yield-curve slope, monetary tightness, fiscal stress.
Real policy rate	Derived	Central Bank, scoring	percentage points	calculated	Derived from policy rate and CPI	Demo/live depends on input series	policyRate - CPI	Explicitly defined in src/app/central-bank/page.tsx and src/lib/scoring.ts.
10-year government yield	YIELD_10Y	Country, Central Bank, Credit, scoring	%	monthly	FRED, OECD, market data, demo cache	Dashboard uses demo cache; FRED/OECD where configured	Direct source/demo value	Used in curve slope.
Yield-curve slope	Derived	Central Bank, Credit, scoring	percentage points	calculated	Derived	Demo/live depends on input series	yield10y - policyRate	Negative values flag inversion in central-bank and credit pages.
Fiscal balance	FISCAL_BALANCE	Country, Fiscal, AI Report	% of GDP	annual	IMF / World Bank / demo cache	Dashboard uses demo cache	Direct source/demo value	Used in fiscal stress and debt arithmetic as primary-balance proxy.
Debt-to-GDP	DEBT_GDP	Country, Fiscal, scoring	% of GDP	annual	World Bank / IMF / demo cache	Dashboard uses demo cache	Direct source/demo value	Used in fiscal stress and debt arithmetic.
Nominal GDP growth	Derived	Fiscal	%	calculated	Derived from GDP growth and CPI	Demo/live depends on input series	GDP_GROWTH + CPI	Used only in fiscal page debt arithmetic.
Current account balance	CURRENT_ACCOUNT	Country, External, AI Report, scoring	% of GDP	annual	World Bank / IMF / demo cache	Dashboard uses demo cache; World Bank/IMF where available	Direct source/demo value	Negative values increase external vulnerability.
FX versus USD	FX_USD	External, scoring	index	monthly	Central banks / market data / demo cache	Dashboard uses demo cache; Bank of Canada for CAD/USD where mapped	Direct source/demo value	Higher index implies depreciation in demo interpretation.
FX reserves	RESERVES	External, scoring	index	monthly	IMF / national sources / demo cache	Dashboard uses demo cache; World Bank adapter maps reserves dollar level where configured	Direct source/demo value	Falling reserve delta increases external vulnerability.
External debt	EXTERNAL_DEBT	External scoring	% of GDP	annual	World Bank / demo cache	Dashboard uses demo cache; World Bank adapter maps where available	Direct source/demo value	External debt above 80 contributes to external vulnerability.
Credit growth	CREDIT_GROWTH	Credit, scoring	% y/y	quarterly	BIS / national sources / demo cache	Dashboard uses demo cache	Direct source/demo value	Credit delta and excessive growth contribute to credit

								stress.
Non-performing loans	NPL	Credit, scoring	% of loans	annual	World Bank / demo cache	Dashboard uses demo cache	Direct source/demo value	NPL above 2 contributes to credit stress.
Crude oil	OIL	Dashboard, Inflation, Commodities, Forecasting scenario labels	USD/bbl	monthly	EIA / FRED / demo cache	Dashboard uses demo cache; FRED maps WTI with key	Direct source/demo value	Oil delta contributes to inflation and commodity-exposure scores.
Natural gas index	GAS	Commodities	index	monthly	EIA / demo cache	Dashboard uses demo cache	Direct source/demo value	Displayed but not explicitly included in scoring code.
Copper	COPPER	Commodities	index	monthly	Market data / demo cache	Dashboard uses demo cache	Direct source/demo value	Displayed as industrial-cycle proxy; no explicit scoring coefficient.
Food price proxy	FOOD	Inflation, Commodities	index	monthly	World Bank pink sheet / demo cache	Dashboard uses demo cache	Direct source/demo value	Displayed in chart; no explicit food coefficient is present in scoring code.
Commodity pass-through	Derived concept	Commodities, Inflation explanation, scoring	score contribution	calculated	Derived from oil delta, CPI-target gap, exposure profile	Demo/live depends on input series	See commodity exposure formula	Food/gas/copper pass-through is described in UI copy, but explicit scoring coefficient is only found for oil and CPI-target gap.
Growth momentum score	growthMomentum	Dashboard, Country, Methodology	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	Higher means higher growth risk.
Inflation pressure score	inflationPressure	Dashboard, Inflation, Country, Methodology	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	Higher means higher inflation monitoring priority.
Monetary tightness score	monetaryTightness	Central Bank, Country, Methodology	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	Higher means tighter/restrictive monetary conditions.
Fiscal stress score	fiscalStress	Fiscal, Dashboard, Country, Methodology	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	High values can override regime classification.
Credit stress score	creditStress	Credit, Country, Methodology	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	High values can override regime classification.
External vulnerability score	externalVulnerability	External, Dashboard, Country, Methodology	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	High values can override regime classification.
Commodity exposure score	commodityExposure	Country risk radar, Methodology	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	Based on importer/exporter profile and oil move.
Geopolitical/structural risk score	geopoliticalRisk	Country risk radar	0-100	calculated	Derived	Demo in current dashboard	See Formula Reference	Placeholder heuristic based on income group, region, and external vulnerability.
Country risk score	overallRisk	Dashboard, Country, AI	0-100	calculated	Derived	Demo in current	Weighted sum of	Higher means higher

		Report				dashboard	component risk scores	macro risk/monitoring priority.
Average macro risk score	averageRisk	Dashboard	0-100	calculated	Derived	Demo in current dashboard	Mean of country overallRisk values	Rounded to one decimal place.
Regime classification	regime	Dashboard, Country, AI Report	label	calculated	Derived	Demo in current dashboard	Rule-based classification	See Regime Classification Rules.
Forecasting indicators	ForecastPoint fields	Forecasting Lab, Country CPI forecast	mixed	calculated	Derived from CPI series	Demo in current dashboard	baseline, optimistic, pessimistic, lowerBand, upperBand	See Forecasting Methodology.
AI report indicators	Prompt inputs	AI Country Report	mixed	calculated/direct	Demo/cache plus optional OpenAI	Deterministic fallback unless OpenAI key succeeds	GDP, CPI, unemployment, policy rate, debt, fiscal balance, current account, scores, regime	Report content is generated from retrieved/demo indicators only.

E. Formula Reference

All score formulas below are extracted from `src/lib/scoring.ts` unless otherwise noted. `clamp(x)` means $\min(100, \max(0, x))$. Missing values use fallbacks embedded in code, usually \emptyset , the country inflation target, or another available proxy.

Helper functions

Formula name	Formula	Plain-English explanation	Missing-data handling
Latest value	<code>latestValue(series, indicator) = last sorted observation value</code>	Selects most recent value by date string.	Returns undefined if not found.
Delta over window	<code>delta = latest.value - previous.value, where previous index = max(0, length - 1 - periods)</code>	Measures recent change over a window.	Returns 0 if latest or previous is missing.
Average latest	average of last N values	Recent moving average for score inputs.	Returns undefined if no observations.
Clamp	<code>clamp(x, 0, 100)</code>	Keeps score in 0-100 range.	Non-finite values map to minimum.

Core derived macro variables

Formula name	Mathematical formula	Inputs	Notes
Real policy rate	<code>realPolicyRate = policyRate - CPI</code>	POLICY_RATE, CPI	Used in central bank page and scoring.
Yield-curve slope	<code>curveSlope = yield10y - policyRate</code>	YIELD_10Y, POLICY_RATE	Negative values imply inversion.
Nominal growth proxy	<code>nominalGrowthProxy = max(GDP_GROWTH + CPI, 0.5)</code>	GDP_GROWTH, CPI	Used in fiscal stress score.
Fiscal-page nominal GDP growth	<code>nominalGrowth = GDP_GROWTH + CPI</code>	GDP_GROWTH, CPI	Used in fiscal page debt arithmetic.

Debt arithmetic	$\text{debtArithmetic} = ((\text{policyRate} - \text{nominalGrowth}) / 100) * \text{debt} - \text{fiscalBalance}$	POLICY_RATE, nominalGrowth, DEBT_GDP, FISCAL_BALANCE	The page describes this as (r - g) x debt - primary balance proxy. Since primary balance is unavailable, fiscal balance is used as a proxy.
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Risk score formulas

Score	Formula	Inputs	Weights/thresholds	Interpretation
Growth momentum	$\text{clamp}(42 - \text{gdp} * 5 + \text{max}(0, \text{gdpAverage} - \text{gdp}) * 12 + \text{max}(0, \text{unemploymentDelta}) * 10)$	GDP growth, four-observation GDP average, four-period unemployment delta	Base 42; GDP coefficient -5; below-average growth coefficient 12; unemployment rise coefficient 10	Higher means weaker growth momentum and higher downside risk.
Inflation pressure	$\text{clamp}(25 + \text{max}(0, \text{cpi} - \text{target}) * 16 + \text{max}(0, \text{wageGrowth} - \text{target} - 1) * 5 + \text{max}(0, \text{oilDelta}) * 0.45 + \text{max}(0, \text{fxDelta}) * 1.1)$	CPI, inflation target, wage growth, six-period oil delta, six-period FX delta	Base 25; CPI excess 16; wage excess 5; oil 0.45; FX 1.1	Higher means inflation is above target or pressure is rising.
Monetary tightness	$\text{clamp}(35 + \text{max}(0, \text{realPolicyRate}) * 10 + \text{max}(0, -\text{curveSlope}) * 8 + \text{policyRate} * 1.8)$	Real policy rate, yield-curve slope, policy rate	Base 35; positive real rate 10; inverted curve 8; policy rate 1.8	Higher means more restrictive monetary conditions.
Fiscal stress	$\text{clamp}(20 + \text{max}(0, \text{debt} - 60) * 0.42 + \text{max}(0, -\text{fiscalBalance} - 3) * 7 + \text{max}(0, \text{realPolicyRate} - \text{nominalGrowthProxy} / 3) * 5)$	Debt-to-GDP, fiscal balance, real policy rate, nominal growth proxy	Base 20; debt threshold 60; deficit threshold -3; adverse rate-growth term coefficient 5	Higher means debt, deficit, and rate-growth pressure are elevated.
Credit stress	$\text{clamp}(28 + \text{max}(0, -\text{creditDelta}) * 5 + \text{max}(0, \text{creditGrowth} - 8) * 2 + \text{max}(0, \text{npl} - 2) * 9 + \text{max}(0, -\text{curveSlope}) * 5)$	Credit growth, four-period credit delta, NPL, yield-curve slope	Base 28; negative credit delta 5; credit growth threshold 8; NPL threshold 2; inverted curve 5	Higher means credit cycle risk is elevated.
External vulnerability	$\text{clamp}(25 + \text{max}(0, -\text{currentAccount} - 2) * 9 + \text{max}(0, \text{fxDelta}) * 1.6 + \text{max}(0, -\text{reservesDelta}) * 1.1 + \text{max}(0, \text{externalDebt} - 80) * 0.18)$	Current account, six-period FX delta, six-period reserves delta, external debt	Base 25; current-account deficit threshold -2; external debt threshold 80	Higher means external financing, FX, reserve, or debt pressure is elevated.
Commodity exposure	$\text{clamp}(25 + \text{importer} ? \text{max}(0, \text{oilDelta}) * 0.9 : 0 + \text{exporter} ? \text{max}(0, -\text{oilDelta}) * 0.6 : 0 + \text{max}(0, \text{cpi} - \text{target}) * 4)$	Commodity exposure profile, six-period oil delta, CPI-target gap	Base 25; importer oil-up coefficient 0.9; exporter oil-down coefficient 0.6; CPI excess 4	Higher means country is exposed to energy shocks and inflation spillovers.
Geopolitical/structural risk	$\text{clamp}(26 + \text{highIncome} ? 4 : 14 + \text{Latin/South region} ? 8 : 0 + \text{max}(0, \text{externalVulnerability} - 65) * 0.2)$	Income group, region, external vulnerability	Base 26; high-income add 4, others add 14; Latin/South add 8; external vulnerability threshold 65	Placeholder non-cyclical risk heuristic.
Overall country risk	$\text{clamp}(\text{growthMomentum} * 0.14 + \text{inflationPressure} * 0.16 + \text{monetaryTightness} * 0.12 + \text{fiscalStress} * 0.15 + \text{creditStress} * 0.13 + \text{externalVulnerability} * 0.13 + \text{commodityExposure} * 0.08 + \text{geopoliticalRisk} * 0.09)$	All component scores	Weights sum to 1.00	Composite macro risk/monitoring score.
Average macro risk	$\text{round1}(\text{sum}(\text{country.overallRisk}) / \text{numberOfCountries})$	Overall risk across all countries	Equal country weights	Displayed on Global Dashboard.

Risk labels and display thresholds

`riskLabel(score)` in `src/lib/format.ts` maps scores as follows:

Score range	Label
≥ 75	High
≥ 55 and < 75	Elevated
≥ 35 and < 55	Watch
< 35	Low

Rule-based central-bank signal

Defined in `src/app/central-bank/page.tsx`:

Condition	Signal
$\text{realRate} > 1$ and $\text{yieldCurveSlope} < 0$	Hawkish / restrictive
$\text{realRate} < 0$	Dovish / accommodative
Otherwise	Balanced

Missing-data handling

The score code uses these fallbacks:

- GDP growth defaults to 0.
- GDP average defaults to latest GDP growth.
- CPI defaults to country inflation target.
- Unemployment, FX, oil, credit, and reserves deltas default to 0 through `deltaOverWindow`.
- Policy rate defaults to 0.
- 10-year yield defaults to policy rate.
- Debt, fiscal balance, current account, credit growth, NPL, external debt default to 0.
- Wage growth defaults to CPI.

F. Regime Classification Rules

Regime logic is defined in `src/lib/regime.ts`. Rules are evaluated in order; earlier rules override later rules.

Regime	Trigger condition	Indicator inputs	Thresholds	Interpretation
Fiscal stress	$\text{fiscalStress} \geq 76$	Fiscal stress score	76	Debt, deficits, and rate-growth dynamics dominate the current risk map.
External stress	$\text{externalVulnerability} \geq 76$	External vulnerability score	76	External funding, FX pressure, or reserve trends dominate.
Credit stress	$\text{creditStress} \geq 76$	Credit stress score	76	Credit-cycle stress overrides baseline growth signal.

Stagflation	growthMomentum >= 58 and inflationPressure >= 62	Growth momentum and inflation pressure scores	58 and 62	Growth is soft while inflation pressure remains high.
Recession risk	growthMomentum >= 68 OR (GDP growth < 0.5 and unemploymentTrend > 0.2)	Growth score, GDP growth, four-period unemployment trend	68, 0.5, 0.2	Weak output momentum and labor-market softening.
Disinflationary growth	GDP growth > 1 AND CPI trend < 0 AND CPI <= inflationTarget + 1.2	GDP growth, six-period CPI trend, CPI, inflation target	1, 0, target + 1.2	Growth remains positive while inflation eases toward target.
Slowdown	growthMomentum >= 48 OR creditStress >= 55	Growth score, credit stress score	48, 55	Not recessionary, but growth/credit are losing momentum.
Expansion	Default if no prior rule matches	All above indirectly	Not applicable	Growth positive, inflation manageable, credit contained.

Regime confidence values are constants in the code: Fiscal stress 0.78, External stress 0.76, Credit stress 0.74, Stagflation 0.72, Recession risk 0.70, Disinflationary growth 0.68, Slowdown 0.64, Expansion 0.66.

G. Risk Score Methodology

Each score measures a monitoring priority rather than a probability. Scores are normalized through the `clamp` function to stay between 0 and 100. The formulas are rule-based heuristics with explicit coefficients and thresholds, not statistically estimated models.

The current country dashboard calculation path is:

17. `getCountryMacroView(countryCode)` loads deterministic demo observations from `src/lib/demo-data.ts`.
18. `calculateRiskScores(country, observations)` computes component scores and overall risk.
19. `classifyMacroRegime(country, observations, scores)` assigns a regime label.
20. `generateCountryReport(...)` creates deterministic report text unless `OpenAI` is enabled and succeeds.

Interpretation:

- 0-34.9: Low monitoring concern.
- 35-54.9: Watch.
- 55-74.9: Elevated.
- 75-100: High.

Limitations:

- Scores are illustrative and rule-based.
- Coefficients are not estimated from historical crisis data.
- Current dashboard scores are demo-data-based, not live-data-based.
- Missing-data fallbacks can lower or smooth risk if a live series is absent.
- The geopolitical/structural score is a placeholder heuristic.

H. Forecasting Methodology

Forecasting code is in `src/lib/forecast.ts`. The app currently forecasts CPI in the country profile and Forecasting Lab.

Date stepping

Date format	Next date logic
YYYY-QN	Adds periods as quarters.
YYYY	Adds periods as years.
YYYY-MM	Adds periods as months.

Trend estimate

$\text{trend} = (\text{lastValue} - \text{priorValue}) / \max(\min(\text{values.length} - 1, 4), 1)$ where $\text{priorValue} = \text{values}[-4]$ if present, else first value, else last value.

Forecast methods

Method	Formula	Inputs	Output	Limitation	Appropriate use
Last observation carried forward	$\text{baseline} = \text{lastValue}$	Latest observation	Flat baseline path	Ignores trend and cycles	Conservative benchmark.
Linear trend	$\text{baseline} = \text{lastValue} + \text{trend} * \text{step}$	Latest value, recent trend, step	Trend extension	Sensitive to recent endpoint changes	Simple directional scenario.
Moving average	$\text{baseline} = \text{average}(\text{last 5 of values plus lastValue} + \text{trend} * \text{step})$	Recent values and projected trend point	Smoothed baseline	Not a structural forecast	Research triage and visualization.

Scenario bands

For each forecast point:

- $\text{confidenceWidth} = \max(\text{abs}(\text{trend}) * \text{step} + \text{abs}(\text{baseline}) * 0.04, 0.4)$
- $\text{optimistic} = \text{baseline} - \text{confidenceWidth} * 0.55$
- $\text{pessimistic} = \text{baseline} + \text{confidenceWidth} * 0.75$
- $\text{lowerBand} = \text{baseline} - \text{confidenceWidth}$
- $\text{upperBand} = \text{baseline} + \text{confidenceWidth}$

The terms "optimistic" and "pessimistic" are generic labels. For CPI, lower inflation is treated as optimistic and higher inflation as pessimistic. This may not be appropriate for every indicator without adjustment.

Scenario shock cards

The Forecasting Lab displays oil shock, dollar shock, rate shock, fiscal shock, and credit shock cards. These are explanatory scenario labels in `src/app/forecasting/page.tsx`; no separate quantitative shock formula is explicitly defined in the current codebase.

I. Data Source Reference

Source name	Adapter name	API endpoint or base URL	API key required?	Environment variable	Indicators supported in code	Coverage	Frequency	Current app status	Notes
Demo data	DemoDataAdapter	<code>src/lib/demo-data.ts</code>	No	None	All current indicators	All MVP	mixed	healthy/demo	Main dashboard

						countries			currently uses this source for country views.
World Bank API	WorldBankAdapter	https://api.worldbank.org/v2/country/{code}/indicator/{indicator}	No	None	GDP_GROWTH, CPI, UNEMPLOYMENT, CURRENT_ACCOUNT, EXTERNAL_DEBT, RESERVES	Countries with WB coverage	annual	live where API succeeds; fallback available	No-key public API.
FRED API	FredAdapter	https://api.stlouisfed.org/fred/series/observations	Yes	FRED_API_KEY	CPI, UNEMPLOYMENT, POLICY_RATE, YIELD_10Y, OIL	U.S.	mixed	degraded/demo without key	Preferred for U.S. overlapping indicators where configured.
BLS API	BlsAdapter	https://api.bls.gov/publicAPI/v2/timeseries/data/	Yes	BLS_API_KEY	CPI, UNEMPLOYMENT, WAGE_GROWTH	U.S.	monthly	degraded/demo without key	Uses POST request for series data.
BEA API	BeaAdapter	https://apps.bea.gov/api/data	Yes	BEA_API_KEY	Health check only in current code	U.S.	mixed	degraded/demo without key	fetchSeries not implemented beyond base keyed adapter.
Statistics Canada WDS	StatCanAdapter	https://www150.statcan.gc.ca/t1/wds/rest/getCodeSets	No	None	Health check/search only	Canada service metadata	mixed	live health if reachable; demo dashboard fallback	Vector mappings not wired into dashboard series.
Bank of Canada Valet API	BankOfCanadaAdapter	https://www.bankofcanada.ca/valet/observations/{series}/json	No	None	FX_USD, POLICY_RATE	Canada	daily	live where requested; fallback available	Maps FXUSDCAD and V39079.
EIA API	EiaAdapter	https://api.eia.gov/v2/	Yes	EIA_API_KEY	Health check only in current code	Energy metadata	mixed	degraded/demo without key	Commodity dashboard uses demo cache.
IMF DataMapper	ImfAdapter	https://www.imf.org/external/datamapper/api/v1/	No	None	GDP_GROWTH, CPI, UNEMPLOYMENT, CURRENT_ACCOUNT	Countries mapped in adapter	annual	optional/secondary; may show access-restricted 403 on server hosts	Uses Accept JSON and User-Agent headers; demo fallback active on 403.
OECD Data Explorer SDMX	OecdAdapter	https://sdmx.oecd.org/public/rest/data/...	No	None	GDP_GROWTH, CPI, UNEMPLOYMENT, YIELD_10Y where mapped	Currently U.S. mappings in code	mixed	live if copied URL works; demo fallback on mapping/parser errors	Mapping file is src/lib/data/oecd-mappings.ts.
BIS Data	BisAdapter	https://stats.bis.org/api/v2/data/dataflow/BIS/...	No	None	POLICY_RATE	Countries mapped in adapter	monthly	live where series exists; demo fallback	Uses CSV parsing.
ECB / Eurostat	EcbEurostatAdapter	https://data-api.ecb.europa.eu/service/data/...	No	None	Health check only	Euro-area financial data health check	mixed	live health if reachable; dashboard demo fallback	Indicator mappings need expansion.
Alpha	Not implemented as	Not present in adapter code	Yes if	ALPHA_VANTAGE_API_KEY	Not implemented	Not	Not	Environment	Reserved for

Vantage	adapter		implemented			explicitly defined in current codebase	explicitly defined	variable documented only	market-data expansion.
OpenAI API	generateCountryReport	https://api.openai.com/v1/responses	Yes	OPENAI_API_KEY, OPENAI_MODEL	AI report text generation	Country report text	on request	deterministic fallback without key or failed request	Does not change numeric scores.

J. Environment Variables

Variable	Required?	Used in code?	Purpose	Commit to GitHub?	Vercel location
NEXT_PUBLIC_APP_NAME	Optional	Yes	Public app name in UI.	Safe but not necessary	Vercel Project Settings -> Environment Variables
FRED_API_KEY	Optional	Yes	Enables FRED live adapter.	Never commit real key	Vercel Project Settings -> Environment Variables
BLS_API_KEY	Optional	Yes	Enables BLS live adapter.	Never commit real key	Vercel Project Settings -> Environment Variables
BEA_API_KEY	Optional	Yes	Enables BEA health check.	Never commit real key	Vercel Project Settings -> Environment Variables
EIA_API_KEY	Optional	Yes	Enables EIA health check.	Never commit real key	Vercel Project Settings -> Environment Variables
OPENAI_API_KEY	Optional	Yes	Enables OpenAI-generated report text.	Never commit real key	Vercel Project Settings -> Environment Variables
OPENAI_MODEL	Optional	Yes	Defaults to gpt-4.1-mini.	Safe but normally environment-specific	Vercel Project Settings -> Environment Variables
ALPHA_VANTAGE_API_KEY	Optional/reserved	Documented, not used in adapter code	Future market-data expansion.	Never commit real key	Vercel Project Settings -> Environment Variables

.env.local and real API keys must not be committed.

K. Live, Demo, and Fallback Data Policy

Status semantics are defined by adapter health output and the Data Sources page:

Status/category	Meaning
healthy/live	A live API connected and returned data, or the local demo source is available.
degraded/demo	Live data did not load, a key is missing, a mapping is absent, or a remote source blocked server access, so demo fallback is active.
fallback	The app continues to display deterministic demo data rather than failing the user experience.
unavailable	Adapter is missing, not implemented, or failed with no fallback available.

mapping-error	An indicator/country mapping or copied endpoint is invalid.
parser-error	HTTP 200 succeeded but the response shape could not be parsed into observations.
network-error	Fetch failed before a usable response was returned.
access-restricted	Remote source blocked the server request, such as IMF DataMapper HTTP 403 from Vercel.
unmapped	A no-key source is reachable or known, but the indicator URL/vector is not mapped yet.

HTTP handling:

- IMF HTTP 403: known source access restriction; health message says IMF DataMapper blocked the server request with HTTP 403 and demo fallback is active.
- OECD HTTP 422: treated as mapping error with response body preview and copied-URL guidance.
- HTTP 404: treated as invalid endpoint/mapping where applicable.
- Missing key: key-based adapters report degraded/demo and state which environment variable is missing.

L. Data Quality and Limitations

This is an MVP, not an official macroeconomic forecasting system.

Limitations:

- The main dashboard currently calculates country scores from deterministic demo data.
- Live adapters are present, but not yet integrated into `getCountryMacroView`.
- Demo values are synthetic and should not be interpreted as official statistics.
- API availability, rate limits, server restrictions, and endpoint changes can affect live adapter health.
- Country coverage differs across sources.
- Formulas are transparent but heuristic; they are not econometrically estimated.
- Scenario forecasts are simple extrapolations with illustrative bands.
- OpenAI report generation, when enabled, summarizes provided inputs and does not validate official data independently.

Disclaimer:

Forecasts, classifications, and risk scores are for research, education, and decision-support only. They are not investment, legal, tax, or financial advice. They are not official forecasts.

M. Reproducibility Guide

To reproduce calculations:

21. Clone the repository.
22. Install dependencies with `npm install`.
23. Copy `.env.example` to `.env.local` if testing live adapters locally.
24. Add optional API keys for FRED, BLS, BEA, EIA, and OpenAI.
25. Run `npm run build`.
26. Run `npm test`.
27. Open the app locally with `npm run dev`.
28. Inspect `/data-sources` to confirm adapter status.
29. Verify demo calculations by reading `src/lib/demo-data.ts`, `src/lib/scoring.ts`, `src/lib/regime.ts`, and `src/lib/forecast.ts`.
30. Compare live adapter values with official source pages when using a live API.

N. Appendix A: Source-Code Map

File path	What the file controls	Formulas found there	Indicators found there	Tests related to it
src/lib/constants.ts	Countries, indicators, disclaimer, app name	No score formulas	All indicator definitions and country metadata	Indirect through app/tests
src/lib/demo-data.ts	Deterministic demo data generation	Demo time-series generation: latest - slope * distance + sine wave * volatility	All demo indicator profiles	Indirect through adapter/scoring tests
src/lib/format.ts	Formatting, latest values, deltas, risk labels	clamp, deltaOverWindow, averageLatest, riskLabel thresholds	Generic helper functions	Used by scoring/regime tests
src/lib/scoring.ts	Risk score calculations	All component score formulas and overall risk weights	GDP, CPI, unemployment, policy rate, yield, debt, fiscal, external, commodity, credit	tests/scoring.test.ts
src/lib/regime.ts	Regime classification	Ordered rule-based regime logic	GDP, CPI, unemployment, risk scores	tests/regime.test.ts
src/lib/forecast.ts	Forecast generation	last, moving average, linear trend, confidence bands	Any passed series, currently CPI in pages	tests/forecast.test.ts
src/lib/ai-report.ts	Deterministic and OpenAI report generation	Deterministic text composition; no numeric scoring formulas	GDP, CPI, unemployment, policy, debt, fiscal, current account	tests/ai-report.test.ts
src/lib/data/service.ts	Country views, global dashboard, tracker rows, source coverage	Average macro risk and rankings	All indicators via demo observations	Indirect through pages
src/lib/data/adapters.ts	Live/demo adapter classes and source health	CSV/JSON parsing helpers; no risk formulas	Adapter-specific indicator mappings	tests/adapters.test.ts
src/lib/data/oecd-mappings.ts	OECD copied API URLs	URL format helper only	OECD GDP, CPI, unemployment, 10-year yield mappings	tests/adapters.test.ts
src/app/dashboard/page.tsx	Global dashboard UI	Regime count and average risk display from service	Overall risk, inflation/fiscal/external rankings, oil	Indirect
src/app/country/[countryCode]/page.tsx	Country profile UI	CPI forecast call	GDP, CPI, unemployment, policy, yield, debt, fiscal, current account	Indirect
src/app/inflation/page.tsx	Inflation tracker	No new formula; displays inflation score	CPI, wage growth, oil, food	Indirect
src/app/central-bank/page.tsx	Monetary policy monitor	realRate, yieldCurveSlope, policy signal	policy rate, CPI, 10-year yield	Indirect
src/app/fiscal/page.tsx	Fiscal monitor	nominalGrowth, debtArithmetic	debt, fiscal balance, GDP, CPI, policy rate	Indirect
src/app/credit/page.tsx	Credit cycle monitor	curveSlope	credit growth, NPL, yield, policy rate	Indirect
src/app/external/page.tsx	External vulnerability page	No new formula; displays external score	current account, FX, reserves	Indirect
src/app/commodities/page.tsx	Commodity tracker	No new formula; pass-through explanation	oil, gas, copper, food	Indirect
src/app/forecasting/page.tsx	Forecasting lab UI	Calls forecast methods; scenario cards are descriptive	CPI	tests/forecast.test.ts
src/app/ai-report/page.tsx	AI country report UI	No new formula	Overall risk, regime, report mode	tests/ai-report.test.ts
src/app/data-sources/page.tsx	Adapter health UI	No new formula	Adapter metadata	tests/adapters.test.ts
src/app/methodology/page.tsx	In-app method summary	Narrative only	Score categories/regimes	Indirect

O. Appendix B: Glossary

- GDP growth: Real output growth, used as the main growth momentum anchor.
- CPI: Headline consumer price inflation.
- Unemployment: Labor-market slack indicator.
- Policy rate: Primary short-term central bank policy-rate proxy.
- Real policy rate: Policy rate minus CPI inflation.
- Yield curve: Difference between long-term yield and short-term/policy rate; in this app, 10-year yield minus policy rate.
- Fiscal balance: Government budget balance as a share of GDP.
- Debt-to-GDP: Government debt burden relative to GDP.
- Current account: External balance as a share of GDP.
- Reserves: Foreign-exchange reserve proxy or level/index depending on source.
- Credit growth: Private credit growth proxy.
- NPL: Non-performing loans as a share of loans.
- External vulnerability: Rule-based score combining current-account, FX, reserves, and external debt pressure.
- Commodity pass-through: Rule-based link between oil moves, inflation gap, and country commodity exposure.
- Risk score: 0-100 monitoring score, with higher values meaning higher risk.
- Regime classification: Ordered rule-based macro label such as Expansion or Fiscal stress.
- Fallback data: Deterministic demo data used when live data is missing or unavailable.
- Live API data: Observations returned by a live external API adapter.

P. Appendix C: Verification Checklist

Use this checklist before publishing methodology or changing formulas:

- Confirm all score formulas in this document match `src/lib/scoring.ts`.
- Confirm all regime thresholds match `src/lib/regime.ts`.
- Confirm forecast formulas match `src/lib/forecast.ts`.
- Confirm country and indicator inventories match `src/lib/constants.ts`.
- Confirm demo data generation and latest profile values match `src/lib/demo-data.ts`.
- Confirm data-source endpoints and key requirements match `src/lib/data/adapters.ts`.
- Confirm OECD URLs and series IDs match `src/lib/data/oecd-mappings.ts`.
- Confirm live/demo labels on `/data-sources`.
- Confirm missing-key, mapping-error, parser-error, network-error, access-restricted, and unmapped cases are represented.
- Confirm `.env.local` and API keys are not committed.
- Run `npm run build`.
- Run `npm test`.
- Deploy to Vercel and inspect `/data-sources`.
- Confirm WordPress link points to the deployed dashboard or landing page.

Missing or Unclear Formula Items

The following items are not explicitly defined as quantitative formulas in the current codebase:

- Oil shock, dollar shock, rate shock, fiscal shock, and credit shock scenario adjustments are displayed as Forecasting Lab cards, but there is no numeric shock transformation formula.

- Food, gas, and copper are displayed in the commodity tracker, but explicit scoring coefficients are not present for food, gas, or copper. The scoring code uses oil delta and CPI-target gap for commodity exposure.
- Alpha Vantage is documented as an environment variable but no adapter implementation is present.
- Statistics Canada and ECB/Eurostat have health checks but no indicator-specific dashboard series mappings.
- Live adapters are not yet merged into the main `getCountryMacroView` scoring pipeline; the dashboard currently uses demo observations.

Recommended improvements:

- Add a single formula registry or documented constants file for all weights and thresholds.
- Add source-of-truth comments beside each score formula.
- Add tests that snapshot formula weights and regime thresholds.
- Add an explicit live-data merge layer before scoring, with source-priority and fallback rules.
- Add quantitative scenario-shock functions if the Forecasting Lab is meant to simulate shocks numerically.

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